Pheromone Based Swarming for Positionless MAVs

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Swarming without positioning

Application oriented swarm systems as presented in [1] currently rely heavily on global or relative positioning information concerning themselves and their direct neighbors ([2,3,4,5]). However, such information is not always available in real-life applications because of hardware and environmental constraints.

To render a more realistic and achievable system, it was chosen to investigate in 2D simulation the development of swarming algorithms, which are not based on positioning information.

This endeavor is motivated by an application whereby twenty fixed-wing Micro Air Vehicles (MAVs) must organize autonomously to establish a robust multi-hop communication network between two users located on ground. Rather than positioning, MAVs rely only on their own heading information and local communication with neighbors (situated communication [6]).

Swarming MAVs for Communication Relay

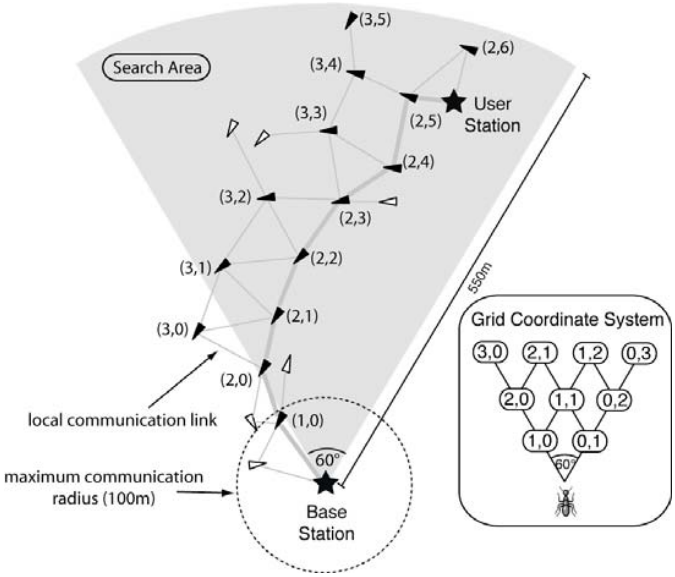

Figure 1. 2D simulation of a deployed swarm of 20 MAVs which must establish and maintain a communication link between a base station and user station. Ant-MAVs (white triangles) navigate through a dynamic grid composed of node-MAVs (black triangles) using pheromone based rules inspired from army ant foraging. Pheromone is virtually deposited and sensed by ant-MAVs using local communication with the node-MAVs. Based on pheromone information and a virtual coordinate system (bottom right corner), ant-MAVs choose between navigating towards the left or the right

In–air virtual pheromone

Inspiration for our MAV controllers is taken from army ants, which are capable of optimally deploying to search for and maintain paths leading to food sources in nature ([7][8]). Ants modify their environment by depositing pheromone and navigate by sensing it (stigmergy). Pheromone based MAV deployments were investigated in [9,10] with MAVs maintaining a virtual map of the pheromone, which is only possible with positioning information.

Instead, the approach proposed here consists in separating the MAVs into two categories 1) node-MAVs and 2) ant-MAVs. Node-MAV constitute the environment on which pheromone can be deposited and read from. Ant-MAVs are capable of navigating through a “grid” of node-MAVs while depositing virtual pheromone through

the use of local wireless communication. MAVs can reactively change between categories to render a highly dynamic network.

Results

Results show that despite the high dynamics of the system (MAVs must be constantly in movement unlike hovering platforms), the swarm is capable of efficiently finding more than 99% of the user stations positioned in the search area shown in figure 1. The connection between the base and user station is then maintained in a stable and robust manner throughout the 30 minutes trial duration.

In the future, we intend to extend such algorithms to systems with multiple or dynamic user stations while increasing the realism of the simulations (3D environment, wind). Also, currently collision avoidance is assumed unnecessary and will have to be implemented through altitude differentiation in the 3D version.

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